Automated Copying of Schematics and PCB Layouts

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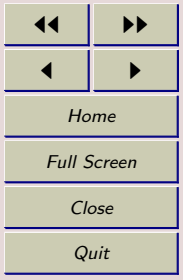
Contents

Overview
Creating a Design
sch-matrix
pcb-matrix
Creating Configuration Files
Example – Electronic Load
Load Schematic
Load PCB
PCB Configuration File . . .
Schematic Configuration . . .
References
Change Log
License


Contents
Overview
Creating a Design
sch-matrix
pcb-matrix
Creating Configuration Files
Example – Electronic Load
Load Schematic
Load PCB
PCB Configuration File . . .
Schematic Configuration . . .
References
Change Log
License



1 Overview

The scripts pcb-matrix and sch-matrix replicate PCB and schematic structures by copying an input file to an output file multiple times incrementing the `(x,y)` position of each copy. The copied structures are arranged in a matrix as specified in a configuration file.

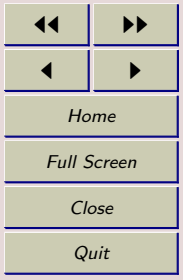
N.B. These scripts may not work for all layouts. I wrote sufficient code to copy the schematic and PCB elements for one of my designs not for all possible designs.

Conventions

⟨*parameter*⟩	Replace with the value of *parameter*
`verbatim text`	Verbatim text when associated with a command or contents of a file.
`sch-matrix`	The current version of the schematic matrix program.
`pcb-matrix`	The current version of the PCB matrix program.
`sch-matrix_`⟨*version*⟩	Version ⟨*version*⟩ of the schematic matrix program.
`pcb-matrix_`⟨*version*⟩	Version ⟨*version*⟩ of the PCB matrix program.

Question, comments, observations, unmarked bills to jluciani at gmail dot com

Contents
Overview
Creating a Design
sch-matrix
pcb-matrix
Creating Configuration Files
Example – Electronic Load
Load Schematic
Load PCB
PCB Configuration File . . .
Schematic Configuration . . .
References
Change Log
License



2 Creating a Design

To create a design:

create an input schematic	Create a schematic that contains the structure to be replicated.
create an input PCB	run `gschpcb` on the input schematic and create a PCB layout (which will be the input PCB layout).
add the marker line to the input PCB	using your favorite editor (emacs) add the marker line to the input PCB.
create configuration files	create configuration files for `sch-matrix` and `pcb-matrix`.
create an output schematic	run `sch-matrix`
create an output PCB	run `pcb-matrix`

If all of the reference designators are assigned in the input schematic and that schematic is used to create the input PCB file then all of the reference designators in the output schematics and PCB files will be in-sync. `sch-matrix` and `pcb-matrix` use the same algorithm to update reference designators.

Contents
Overview
Creating a Design
sch-matrix
pcb-matrix
Creating Configuration Files
Example – Electronic Load
Load Schematic
Load PCB
PCB Configuration File . . .
Schematic Configuration . . .
References
Change Log
License

Home
Full Screen
Close
Quit

3 sch-matrix

Usage

`sch-matrix_0` ⟨*configuration filename*⟩

Description

The `sch-matrix` script creates a new layout by coping each `component`, `text` value, `net`, `line` and `circle` to an output file multiple times. Each structure is positioned as defined by the parameters in the configuration file. For each `component` the reference designator is updated to maintain unique reference designators in the output file.

3.1 Creating the Schematic

Schematics are created in the usual manner using `gschem`. Prior to running `sch-matrix` all of the reference designators (refdes's) must be assigned. `sch-matrix` dies if the refdes does not match an alphabetic string followed by integer (*which is the regular expression* `[A-Za-z]+\d+`).

3.2 Connecting the Replicated Schematics

The replicated schematics can be connected by naming nets or by placing nets so that they will physically connect after replication. Naming the nets produces less clutter on the schematic but does not show connectivity. Using continous nets shows connectivity but can be messy when there are many nets or nets in many directions (such as when groups of components are arranged in a matrix).

If the groups are all in a row (or all in a column) then a continous horizontal (or vertical) net can be placed. By choosing the appropriate length for the net and the proper `xoffset` and `yoffset` a single continous net will be created in the output file. For a matrix a combination of net names and continuous nets may be best.

3.3 Adding Circuitry to the Output Schematic

Usually additionaly circuitry will need to be added to the output schematic to complet a design. However, everytime `sch-matrix` is run the output schematic is overwritten. If you embed the output schematic in your design using a heirachical block then this problem is eliminated. Since connections to the block are by net names no changes are required when `sch-matrix` is re-run.

Contents
Overview
Creating a Design
sch-matrix
pcb-matrix
Creating Configuration Files
Example – Electronic Load
Load Schematic
Load PCB
PCB Configuration File . . .
Schematic Configuration . . .
References
Change Log
License

4 pcb-matrix

Usage

`sch-matrix_0` ⟨*configuration filename*⟩

Description

The `pcb-matrix` script creates a new layout by coping each `Element`, `Polygon`, `Via` and `Line` from an input file to an output file multiple times. Each layout, from the input file, is positioned as defined by the parameters in the configuration file. For each `Element` the reference designator is updated to maintain unique reference designators in the output file.

In a PCB file there is a variety of data prior to the start of the layout (*e.g.* user interface settings, character symbols) . It does not seem desirable to replicate all of that data. Rather than try to guess where the layout starts the `pcb-matrix` program requires a marker line in the input file to indicate the start of the layout. The marker line is a line containing only the string `#####__PCB__#####` which is a legal PCB comment line. This marker line has to be reinserted each time you save the PCB layout.

The start of the layout seems to reside after all of the symbol declarations and before the vias. `pcb-matrix` will copy all of the lines prior to the marker to the output file verbatim. After the marker line is read the remaining lines will be output $r \cdot c$ times in a matrix (where r is the number of rows and c is the number of columns specified in the configuration file).

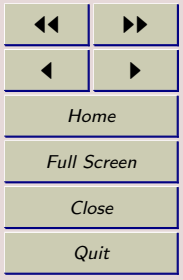
4.1 Adding Circuitry to the Output PCB Layout

Usually additionaly circuitry will need to be added to the output PCB layout to complet a design. However, everytime `pcb-matrix` is run the output layout is overwritten.

If you embed the output layout in your design using the `load layout data to paste-buffer` command then you can reload it if changes need to be made. Since the output layout is self-contained only the peripheral connections will need to updated. To reload an output layout into your design:

1. Delete the peripheral connections that connect the output layout to your design.
2. Delete the output layout.
3. Use `load layout data to paste-buffer` to add the output layout
4. Add the peripheral connections.

Contents
Overview
Creating a Design
sch-matrix
pcb-matrix
Creating Configuration Files
Example – Electronic Load
Load Schematic
Load PCB
PCB Configuration File . . .
Schematic Configuration . . .
References
Change Log
License



5 Creating Configuration Files

The configuration file format is the same for `sch-matrix` and `pcb-matrix`. Each file can contain comments, empty lines and lines that set parameters. Comments start with a `#` and proceed to the end of the current line. Comments and empty lines are ignored by the parser. The lines that set parameters are in the format:

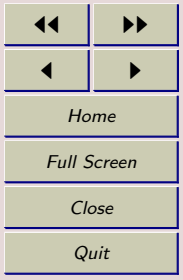
⟨*parameter name*⟩ | ⟨*parameter value*⟩

where ⟨*parameter name*⟩ is one of the names listed in Table 1.

Name	Type of Value	Description
`x0`	Integer	the x coordinate (in mils) of the starting position in the output file
`y0`	Integer	the y coordinate (in mils) of the starting position in the output file
`xoffset`	Integer	the center-to-center column spacing (in mils)
`yoffset`	Integer	the center-to-center row spacing (in mils)
`last_col`	Ordinal	the ordinal of the last column (column ordinals start at 0)
`last_row`	Ordinal	the ordinal of the last row (row ordinals start at 0)
`input_filename`	String	the name of the file containing the structure that will be replicated
`output_filename`	String	the name of the file that contains the replicated stuctures

Table 1: Configuration File Parameters

Contents
Overview
Creating a Design
sch-matrix
pcb-matrix
Creating Configuration Files
Example – Electronic Load
Load Schematic
Load PCB
PCB Configuration File . . .
Schematic Configuration . . .
References
Change Log
License



6 Example – Electronic Load

Occasionally a circuit design consists of a group of elements, a cell, that needs to be replicated multiple times. One example is an electronic load. An electronic load is a circuit that sinks current and is an essential instrument in power supply test.

Typically an electronic load consists of multiple load-cell circuits in parallel. Creating a load using multiple cells increases the total current sinking capability of the load. A schematic of a simplified load-cell circuit is shown in Figure 1. The circuit consists of an op-amp, an N-channel MOSFET and current sensing resistor.

Contents
Overview
Creating a Design
sch-matrix
pcb-matrix
Creating Configuration Files
Example – Electronic Load
Load Schematic
Load PCB
PCB Configuration File . . .
Schematic Configuration . . .
References
Change Log
License

7 Load Schematic

When creating the load-cell schematic the nets that are to have cell-to-cell connections need to have sufficient length so that they overlap after replication. The ground net and the net from the drain of Q1 (Figure 1) are long enough so that an `xoffset` value of 3200 in the configuration will overlap the nets in the output file.

Prior to running `sch-matrix` all of the reference designators need to be assigned. `sch-matrix` will uniquely number all of the components in the output file based upon the assigned values in the input file.

The configuration file for `sch-matrix` is shown in Listing 2. Lines 12 and 13 define the cell spacing for rows and columns respectively. The values on lines 14 and 15 define a 1x4 matrix.

The output schematic shown in Figure 2 is the result of running `sch-matrix` using the configuration file in Listing 2. Notice that the horizontal nets have been connected and the reference designators of the copied cells have been uniquely assigned.

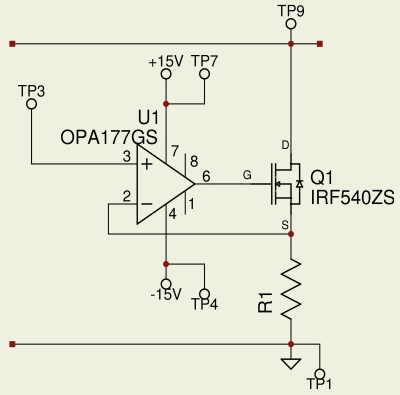


Figure 1: Load-cell Schematic

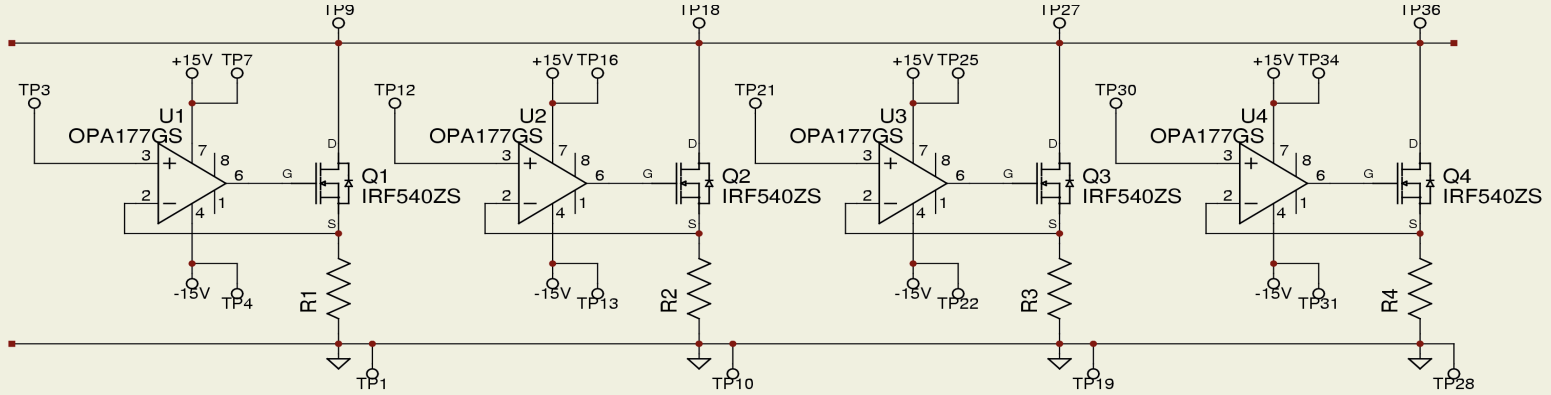


Figure 2: Load Schematic

Contents
Overview
Creating a Design
sch-matrix
pcb-matrix
Creating Configuration Files
Example – Electronic Load
Load Schematic
Load PCB
PCB Configuration File . . .
Schematic Configuration . . .
References
Change Log
License

8 Load PCB

After creating the schematic for the load-cell run `gsch2pcb` and create a layout for a single load-cell. An example load-cell layout is shown in Figure 3.

In the load-cell layout the two high current traces are running parallel on the component side of the board along the top of the cell. The op-amp power and positive-input traces are running parallel on the solder side of the board at the bottom of the cell. All of the parallel traces are ≈ 950mils long. Setting an `xoffset` of 900mils will create an overlap between the cells in the output file.

Running `pcb-matrix` with the configuration file in Listing 1 produces the layout in Figure 4.

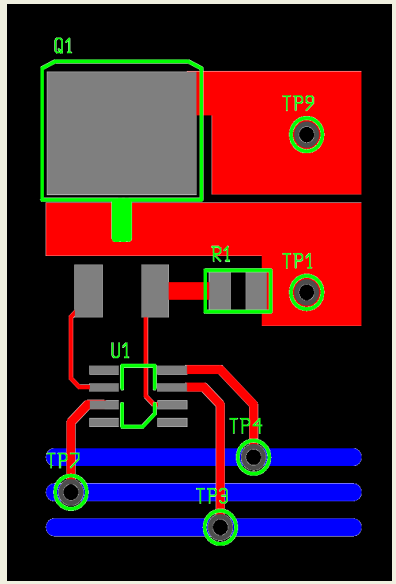


Figure 3: Load-cell PCB

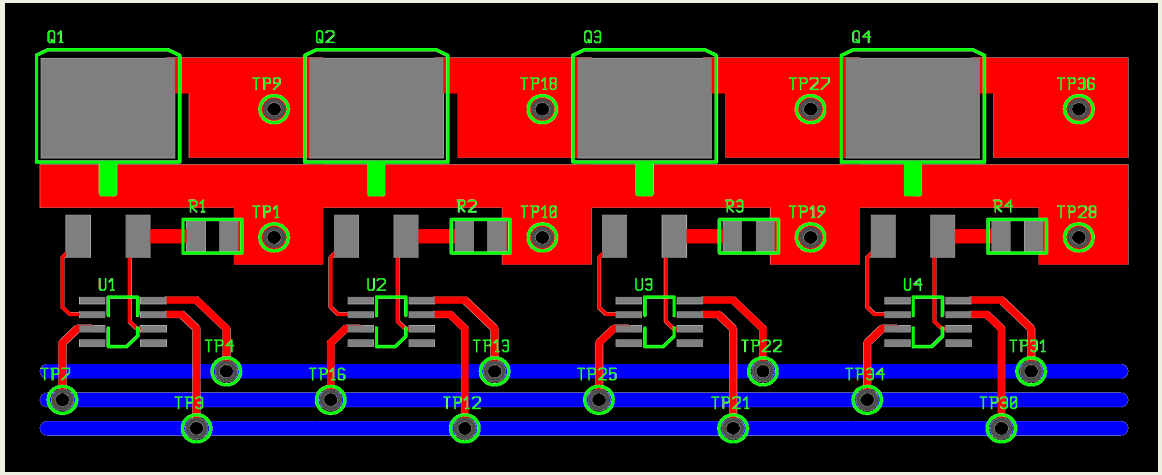


Figure 4: Load PCB

Contents
Overview
Creating a Design
sch-matrix
pcb-matrix
Creating Configuration Files
Example – Electronic Load
Load Schematic
Load PCB
PCB Configuration File . . .
Schematic Configuration . . .
References
Change Log
License

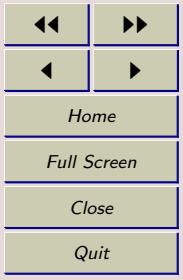
9 PCB Configuration File Example

Listing 1: Configuration File for the Electronic Load PCB

```
# x0          the x coordinate of the starting position in the output file
# y0          the y coordinate of the starting position in the output file
# xoffset     the column spacing
# yoffset     the row spacing
# last_col    the ordinal of the last column (column ordinals start at 0)
# last_row    the ordinal of the last row (row ordinals start at 0)
# input_filename  the name of the file containing the PCB layout that will be replicated
# output_filename the name of the file that contains the replicated PCB layouts

x0              | 500
y0              | 100
xoffset         | 900
yoffset         | 0
last_col        | 3
last_row        | 0
input_filename  | load-cell.pcb
output_filename | load.pcb
```

Contents
Overview
Creating a Design
sch-matrix
pcb-matrix
Creating Configuration Files
Example – Electronic Load
Load Schematic
Load PCB
PCB Configuration File . . .
Schematic Configuration . . .
References
Change Log
License



10 Schematic Configuration File Example

Listing 2: Configuration File for the Electronic Load Schematic

```
1  # x0          the x coordinate of the starting position in the output file
2  # y0          the y coordinate of the starting position in the output file
3  # xoffset     the column spacing
4  # yoffset     the row spacing
5  # last_col    the ordinal of the last column (column ordinals start at 0)
6  # last_row    the ordinal of the last row (row ordinals start at 0)
7  # input_filename  the name of the file containing the PCB layout that will be replicated
8  # output_filename the name of the file that contains the replicated PCB layouts
9
10 x0              | 500
11 y0              | 100
12 xoffset         | 3200
13 yoffset         | 0
14 last_col        | 3
15 last_row        | 0
16 input_filename  | load-cell.sch
17 output_filename | load.sch
```

References

Eaton, H., & Nau, T. (2002). Pcb [Computer software and manual]. (Retrieved February 6, 2005 from http://pcb.sourceforge.net/pcb-20050127.html/index.html)

Hvezda, A. (2003, Dec). gEDA/gaf File Format Document [Computer software and manual]. (Retrieved May 10, 2005 from http://www.geda.seul.org/docs/current/fileformats/index.html)

Contents

Overview
Creating a Design
sch-matrix
pcb-matrix
Creating Configuration Files
Example – Electronic Load
Load Schematic
Load PCB
PCB Configuration File . . .
Schematic Configuration . . .
References
Change Log
License

11 Change Log

`pcb-matrix_0`	Initial Release
`sch-matrix_0`	Initial Release

Contents
Overview
Creating a Design
sch-matrix
pcb-matrix
Creating Configuration Files
Example – Electronic Load
Load Schematic
Load PCB
PCB Configuration File . . .
Schematic Configuration . . .
References
Change Log
License

Contents
Overview
Creating a Design
sch-matrix
pcb-matrix
Creating Configuration Files
Example – Electronic Load
Load Schematic
Load PCB
PCB Configuration File . . .
Schematic Configuration . . .
References
Change Log
License

Home
Full Screen
Close
Quit

12 License

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